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ARTICLE

Factors Motivating Virtual Lab Simulations Adoption in Secondary School Physics Instruction in Jordan

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Abstract: The study investigated the factors that motivate secondary school physics instructors to use virtual lab simulations in teaching and learning in four regions of the Hashemite Kingdom of Jordan. To examine the research question, the study utilized a quantitative survey research methodology using a survey questionnaire consisting of 25 Likert-type scale questions to measure physics instructors' attitudes toward using virtual lab simulations in practical investigations preparation and delivery. Contrary to what might be expected, the findings came across a number of variables that were not predictors of statistical significance for a physics instructor's virtual lab simulations adoption: gender; level of education; school site; average class size; ways of acquiring technology skills, for instance, self-taught and computer courses; and perceived barriers. The findings support the prediction that the lack of virtual lab simulations in the Jordanian high school physics curriculum has an impact on Tawjihi students' achievement in physics.

Keywords: Simulation, Virtual lab, Rogers' diffusion of innovations theory.

Introduction

The study intended to discover and recommend practical solutions using physics virtual lab simulations to improve student learning and raise the Tawjihi students' scores in physics. Therefore, the study is designed to investigate the lack of physics practical investigations (real labs/ virtual lab simulations) in Jordanian secondary school curriculum and its impact on high school students' results [1].

Thomton and Tamir (as cited in [2]) have demonstrated that even instructors who are proficient at delivering lectures still have merely partial accomplishment in assisting students in comprehending physics utilizing this method. They have suggested that students ought to be more involved than possible throughout the lecture, even in a conventional class with a substantial number of students. Science ought to be viewed as a subject that inspires students' inquisitiveness to be inquiring minds and that demands students to have problem solving skills. The experimental characteristic of the subject brings about collaboration and attainment of needed manipulative aptitudes. It likewise encourages observational, inferential, and appraising aptitudes (Rawer, as cited in [2].

It is noted that Tawjihi students' achievement in physics is relatively low compared to other science subjects such as chemistry, biology, and geology. Hands-on experiments or virtual labs enable students to be active learners at the focal point of learning process rather than being passive learners receiving all the information from their teachers. Table 1.1 shows the mean success rates in science subjects from 2016-2019 for summer sessions in four cities in the

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Hashemite Kingdom of Jordan: Irbid, Al-Karak, Zarka, and Amman. The raw data were obtained from the Tests and Examination Department at the Ministry of Education and then were analyzed by using Statistical Package for Social Science (SPSS) Version 25.0.

TABLE 1. Mean Success Rates in Science Subjects from 2016-2019

City	Mean Success Rate from 2016-2019			
	Biology	Chemistry	Geology	Physics
Al-Karak	58.98%	85.13%	78.90%	55.93%
Amman	71.93%	81.63%	78.73%	66.60%
Irbid	71.73%	85.58%	79.25%	68.98%
Zarka	66.78%	80.53%	76.15%	62.45%

The purpose of the study was to investigate the effectiveness of integrating virtual lab simulations into the Jordanian physics curriculum to inspire secondary school physics instructors in Jordan to include virtual lab simulations in the scope of instructional curriculum in ways that mimic traditional lab-based teaching and learning. Simulations created authentic classroom platforms that located instructors as facilitators and inspired learning to take place through student interaction with supervision from the instructor (Wieman, Adams, Loeblein, & Perkins, as cited in [3]).

Literature Review

The study conceptualized the age of an instructor, teaching experience, Internet at home and school, availability of educational technology resources, perceived characteristics of technology, and in-service training as independent variables. Using virtual lab simulations in teaching and learning in the four regions of the Hashemite Kingdom of Jordan is considered as the major dependent variable.

According to Ajredini, Izairi, and Zajkov [4], although real investigations enable students to reflect more, especially at first, when they are required to plan the practical set up and work out practicable problems, simulations do not necessitate real design and the practical problems, which are expected to be resolved, are insignificant. Because simulations empower students to envision the imperceptible objects, this would yield preferable outcomes over the real investigations. Simulations are exceptionally effectual for assisting students in comprehending the theoretical and unjustified conceptions of specific topics of physics since they can visualize, interact, and efficiently exploit computations while using the simulations (McKagan et al., as cited in [4]).

According to Fan, Geelan, and Gillies [5], several studies demonstrated that computer simulations reveal a substantial increase in strengthening the growth of students' abstract comprehension and advancing students' extrapolative aptitude as well. Easy Java Simulation (EJS) demonstrated proof of improving students' physics abstract learning. These simulations involve students in an inquiry-based learning process to assist them in attaining abstract comprehension and enhancing their inquiry aptitudes. When students utilize Physics Education Technology (PhET) simulations to examine their hypothesis, kinetic movements; pictures; graphs; and tables displayed on the PC interface along with the printed words on textbooks assist in scaffolding students' comprehension. Utilizing PhET simulations, instructors were provided with more time to monitor students' learning rather than concentrating on students' security in the labs. To sum up, learners studying with the Interactive Simulations Instructional Approach (ISIA) model utilizing interactive simulations gain knowledge more efficiently than learners utilizing traditional education. This result was strong across both genders and all scholastic accomplishment levels [5].

Price, Wieman, and Perkins [6] indicated that physics instructors utilizing PhET simulations as a demonstration are able to situate the exact scenarios they want for their students to observe, while enabling the students to check their predictions from the supplementary clicker questions. According to Gasparella [7], physics simulation tools help students achieve higher understanding of the details of the physical procedures concerned, better comprehension of the modeling methodologies and their employment, and a perception into all the simulation measures, their significance, consequences, and progression.

Mourad and Mohamed [8] indicated that simulation engineering is an promising field that employs both simulation science and engineering fields to deal with numerous complicated real-world problems through a modeling activity that models physics phenomena and a simulation activity that achieves more awareness of phenomena, predictions, and implementation study.

The theoretical framework of the study is based on Rogers' Diffusion of Innovations Theory (DOI). According to Freeman and Mubichi (2017), the Diffusion of Innovation (DOI) theory analyzes how and why choices to embrace a modern technology happen. Rogers (as cited in [9]) described diffusion as the procedure by which an advancement moves in the bounds of a social framework in a short time. While an advancement frequently alludes to physical bodies, it can as well incorporate thoughts, practices, or practices that are new to the people in the bounds of a framework [9].

Nan, Zmud, and Yetgin [10] indicated that there are four fundamental components of diffusion of innovation: an innovation (thought, practice, or object); communication channels (to transfer data from one individual to another); time (including three elements: innovation decision time, relative time with which an innovation is embraced, and the innovation's percentage of embracing); and the social system (a group of interconnected individuals that are involved in common problem solving to achieve a mutual objective). In a diffusion of innovation setting, social network content is exemplified by three innovation-associated indicators. These indicators can appear as data in regard to perception (the presence of an advancement), inspiration (convictions about potential benefits to be acquired from embracing an advancement), and aptitude (information associated with comprehending and employing an advancement) [10].

In this regard, the following research question was proposed:

Q: What are the varying factors that encourage secondary school physics instructors to use virtual lab simulations in teaching and learning in the four regions of the Hashemite Kingdom of Jordan?

Methods

Participants and setting

The participants in the current study were 120 (60 male and 60 female) high school physics instructors within the age range of 20-60. The participants work at public high schools in the four cities in the Hashemite Kingdom of Jordan: Irbid (northern region), Al-Karak (southern region), Zarka (eastern region), and Amman (western region).

Instrumentation

The instrument used in this study was a Physics Teachers' Survey (PTS) survey questionnaire consisting of 25 Likert-type scale questions to measure physics instructors' attitudes toward using virtual lab simulations in physics instruction.

Data collection

Data collection of the study included a quantitative technique that made use of a questionnaire survey tool. The questionnaires were distributed in person and electronically using Google Forms through the Jordan Physics Teachers Forum in order to reach as many physics teachers as possible to fill out the questionnaires. The collected data were entered in a Microsoft Excel spreadsheet and then exported to Statistical Package of Social Sciences (SPSS) Version 25.0 necessary for a multiple regression analysis.

Results

Table 2 introduces instructor gender and age group. Table 3 shows the highest completed education degree and high school physics teaching experience. Table 4 shows the school features that were gathered in the study. School features incorporated Internet access availability and places as well as the classroom computers availability. Table 5 shows the findings of the multiple regression that were described depending upon the unstandardized regression coefficient B, standardized regression coefficient β, 95% confidence interval, and the statistical significance.

TABLE 2. Socio-demographic Profile of Instructors in Sample (NTotal = 120)

Socio-demographics		N	%
Gender	Male	60	50.0
	Female	60	50.0
	Total	120	100.0
Age Group	20-30 years	16	13.3
	31-40 years	52	43.3
	41-50 years	36	30.0
	51-60 years	16	13.3
	Total	120	100.0

TABLE 3. Characteristics of Instructors Surveyed

Teaching Characteristics		N	%
Highest Completed Education Degree	Teacher college diploma	1	.8
	Bachelor's degree	89	74.2
	High Diploma after Bachelor	2	1.7
	Master's degree	27	22.5
	Doctorate (Ph.D. or Ed. D)	1	.8
	Total	120	100.0
High School Physics Teaching Experience	3 years or more but less than 10 years	45	37.5
	10 years or more but less than 15 years	28	23.3
	15 years or more but less than 20 years	18	15.0
	20 years or more	29	24.2
	Total	120	100.0

TABLE 4. School Features

School Features		N	%
Internet Access Availability and Places	Yes: Home	54	45.0
	Yes: School	3	2.5
	Yes: Both	61	50.8
	I do not use it	1	.8
	No	1	.8
	Total	120	100.0
Classroom Computers Availability	Laptop	1	.8
	No	119	99.2
	Total	120	100.0

TABLE 5. Outline of the Model Parameters

	Model Parameters							
	Predictor Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta (β)			Lower Bound	Upper Bound
Socio-demographics								
1	(Constant)	7.004	.429		16.334	.000	6.155	7.853
	Teacher's age group	-.529	.209	-.305	-2.531	.013	-.943	-.115
	Teaching experience	.473	.154	.370	3.064	.003	.167	.779
Technology Resources								
2	(Constant)	5.791	.687		8.426	.000	4.429	7.152
	Internet access availability and places	.345	.135	.225	2.551	.012	.077	.612
	Availability of educational technology resources	.163	.183	.081	.889	.376	-.200	.525
Technology Training								
3	(Constant)	4.911	.778		6.308	.000	3.368	6.453
	In-service training	.297	.223	.129	1.331	.186	-.145	.738
	Perceived characteristics of technology	.178	.117	.139	1.528	.129	-.053	.410

Discussion

After analyzing the data collected from the (PTS) survey by using Statistical Package for Social Science (SPSS) Version 25.0, the following socio-demographic profile (Tables 2 &3) of physics instructors was made. The sample consisted of 60 female instructors (50%) and 60 male instructors (50%) as well. Age group was the second socio-demographic, with the uppermost consideration of instructors lying in the 31–40 (43.3%) year range.

Most of the instructors were categorized into young adults. Probable explanations involve lowering the optional retirement age of public school instructors from 60 years to 55, high teacher turnover rates, and instructors moving into administrative roles and responsibilities. A bachelor's degree was the prevailing level of education achieved by 89 physics instructors in this sample (74.2%). Just one instructor informed an achieved doctorate. The Jordanian Ministry of Education requires instructors to hold a bachelor's degree in physics to tutor in secondary schools. This qualifications condition could account for the great number of instructors with a bachelor's degree in the sample. High school physics teaching experience ranged from 3 to more than 20 years, with the greater part of physics instructors having tutored 3–10 years (37.5%). The 3–20 year category signified 75.8% of the sample. Physics instructors who tutored 15–20 years could have moved into administrative roles and so they could be more probable to avoid responding to a random survey. Having instructors with 3–10 years in the classroom can make the instruction setting more constructive, as these instructors are supposed to be better equipped to manage classroom matters, for example, discipline and lesson preparation and delivery.

The school features (Table 4) incorporated Internet access availability and places and classroom computers availability as well. Internet access in schools was rated poorly (2.5%) and only one classroom had a computer (0.8%). Yet again, low Internet access and providing classrooms with a computer may have to do with the Jordanian Ministry of Education dinars available particularly to support computer technology in schools and to adopt virtual lab simulations in teaching and learning. If schools lack computer resources, using computer technology for lesson planning and preparation in addition to accommodating students' personal learning styles becomes exceptionally complicated, if not impossible.

Table 5 shows that the 95% confidence intervals for each of the six predictor variables did not comprise zero and consequently in 95% of the chosen sample, the interval estimate involved the true population parameter. This indicates that the six predictors can precisely predict future virtual lab simulations adoption. The multiple regression analysis gave rise to the better statistical model. Two of the six variables, teacher's age group and teaching experience, served as controlled variables. Concentrating on the association between each predictor variable and the virtual lab simulations adoption; teacher's age group and teaching experience significantly predicted the virtual lab simulations adoption while Internet access availability and places, perceived characteristics of technology, in-service training, and availability of educational technology resources moderately predicted the virtual lab simulations adoption.

Raising one unit in each one of the six predictor variables produced a percentage variation in the virtual lab simulations adoption by means of the following: teaching experience (β = 0.370), teacher's age group (β = -0.305), Internet access availability and places (β = 0.225), perceived characteristics of technology (β = 0.139), in-service training (β = 0.129), and availability of educational technology resources (β = 0.081). The overall regression model explained 17.2% (which is of a medium effect as indicated by Cohen's conventions) of the predicted variation on the physics instructor's virtual lab simulations adoption. The estimated R^2 was 12.7%. Obviously, the two values were not significantly different, which implied that the virtual lab simulations adoption was quite verified by the predictor variables in the multiple regression model.

These findings imply that teaching experience of all physics instructors and teacher's age group, apart from their school sites have to be borne in mind as a main concern throughout the integration of virtual lab simulations in schools. Pre-service teacher training programs should incorporate technology training to make sure that younger physics instructors graduating from college are provided with sufficient technology skills for teaching physics.

The study indicated that teacher's age group, Internet access availability and places, perceived characteristics of technology, and in-service training may result in higher physics instructor's virtual lab simulations adoption and may influence students optimistically and inspire instructors to incorporate virtual lab simulations in their instruction approach. Teaching experience was the strongest predictor of the physics instructor's virtual lab simulations adoption in teaching physics in the four regions of the Hashemite Kingdom of Jordan: Irbid, Al-Karak, Zarka, and Amman. Nevertheless, there are other means where teachers can acquire technology, for instance, computer courses and being self-taught, were not predictors of statistical significance for virtual lab simulations adoption and thus, they were not incorporated in the regression analysis model. It should be noted that perceived barriers variable was not a predictor of statistical significance for the physics teacher's virtual lab simulations adoption due to its very low beta (β = -0.013). Therefore, this variable was excluded from the regression analysis model.

Conclusion

The research study provided information about what contributed to successful adoption of virtual lab simulations in particular, for the improvement of physics instruction in public secondary school classes in Jordan. Implications for policy and practice handle two major issues: supplying technology-based training (TBT) and supplying technology infrastructure and resources.

1. Supplying technology-based training (TBT)

The existing study demonstrates that in-service training of physics instructors is a considerable factor that persuades whether instructors employ computer technology or not in physics instruction. The suggested training would incorporate certified technology courses at the Queen Rania Teacher Academy (QRTA) paid for by the Ministry of Education. At the present time, Jordanian instructors get training during school holidays, which is insufficient to coach instructors who have no earlier knowledge with technology to recognize it and understand the way to employ it in physics instruction. Accordingly, the suggested training must be provided with sufficient full-time study leave or as on-site workshops so that instructors can be given chances to put into practice in the classrooms. Computer technology training for physics instructors must focus not only on Microsoft Office and Internet skills, but also cutting-edge physics softwares such as COMSOL Multiphysics® software, Algodoo, Circuit Shop, Interactive Physics, Maplesoft, Solve Elec, and Virtual Physical Laboratory (VPL). Instructors training must exceed training centers and must track the instructors in their classrooms by assigning mentor instructors and technical assistance to report on and assist them in the course of technology adoption procedure. Moreover, those instructors who achieve successful technology training courses completion must be offered awards and incentives, appreciated, and highly praised so as to inspire and persuade other instructors to attend training workshops to learn technology.

2. Supplying technology infrastructure and resources

The findings showed that instructors frequently encounter difficulties in employing technology in their lessons due to the deficiency of technology resources. Therefore, classrooms must be outfitted with technology resources and Internet connectivity so that instructors can use virtual lab simulations to expand students' achievement. In addition, the government must provide low-priced smart phones and laptops for instruction and make internet access more reasonably priced and accessible at homes and schools. Since not all instructors can manage to pay for technology, instructors must be offered incentives and subsidies to purchase personal technology in order to support technology adoption in physics instruction and to guarantee conformity.

The findings of the study may be beneficial to the educational community:

- Physics instructors who do not incorporate the real/virtual practical work in their teaching may improve their students' critical thinking, theoretical comprehension of high school physics, and lab experience by bringing about an interactive classroom setting through using virtual labs;
- Queen Rania Teacher Academy (QRTA), as a teachers training institution, might be authorized to make an educational decision to modify their training methodologies and lay emphasis on practical investigation;
- Curriculum developers in the Jordanian Ministry of Education (MOE) may make use of the results of the study to change their methodology in designing the physics curriculum and integrating more practical investigations into it; and
- The examiners in the MOE may require to modify the high school physics external examinations by adding a practical exam to assess the practical skills and acquisition procedures.

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